Spatial Patterns in Soil Geochemistry of the United States: The Relationship between Scale and Process

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Geochemical maps portray the spatial distribution of elements in the medium sampled and provide clues to understand the processes that produce the observed patterns. Geochemical surveys of near-surface soils have been conducted in the United States to delineate patterns in areas ranging from national to regional to local scales. The observed spatial distributions for the elements studied are controlled primarily by natural geochemical processes, such as formation of soils from parent materials of varying composition, and by climate-driven processes that establish soil moisture regimes and levels of organic matter in soil. Anthropogenic influences such as industrialization, urbanization, waste disposal, mining, and agriculture regularly are superimposed on these natural, or background, geochemical distributions. The area of the Earth's surface influenced by these processes may vary from millions of square kilometers to tens of square kilometers. Therefore, the success of any geochemical map in depicting a process pattern is dependent on the density of sampling in the study area.

National-scale geochemical maps of the conterminous United States based on low-density sampling of near-surface soils (1 sample per 6,000 square kilometers) delineate elemental patterns that are related to processes acting over relatively large areas of the country. National-scale distributions of elements such as calcium, magnesium, barium, potassium, sodium, and strontium seem to illustrate the effect of climate-related processes on element distribution. The distributions of metals such as lead and arsenic at this national scale show both the influence of natural geologic processes, such as hydrothermal fluid flow, and possible anthropogenic effects from, for example, proximity to coal-fired power plants.

The stability of geochemical patterns from such low-density national-scale data is commonly questioned given the potential variation of soil geochemistry over relatively small distances. Comparison of the patterns from low-density sampling with much higher resolution geochemical maps produced from airborne gamma-ray surveys and from recently completed continental-scale transects demonstrates that the patterns outlined by low-density sampling are generally replicated at higher resolutions.

Geochemical surveys at regional scales, with sampling densities of 1 sample per 200-500 square kilometers, to more local scales, with 1 sample per 1-5 square kilometers, greatly increase the resolution of the patterns generated in the national-scale studies and lead to the identification of patterns not revealed by

the lower-density surveys. These higher sampling densities permit delineation of features related to processes acting over much smaller areas of the country. At these scales, human activities connected to different types of land use are important controlling factors often superimposed on natural distributions.